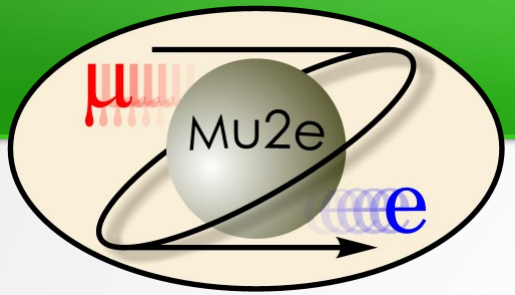


MWPC Tracking Code

Efficiency Improvement

Prof. Dukes, Prof. Group, Martin, Yuri, Yongyi Wu, Enhao Song
University of Virginia

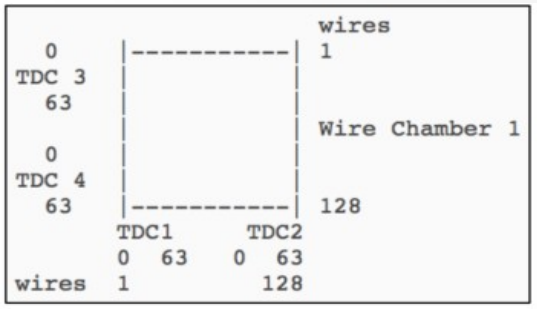
2015/06/17

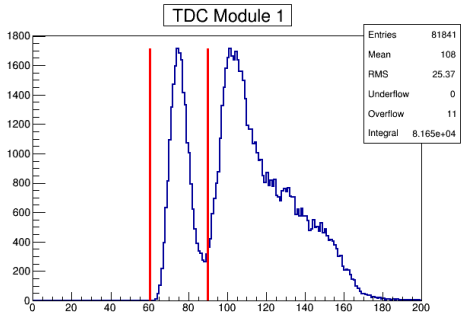
Improve MWPC Tracking Code Efficiency

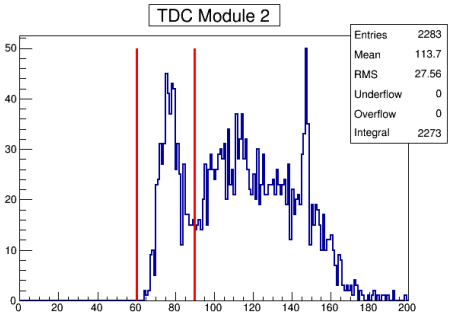
- We want to know the proton position at the CRV counter.
- Our test beam area has 4 MWPC stations along the beam axis that can be used to track the proton.
- Martin suggested me to improve the tracking code:
  - Martin's code compiles and run on Mu2e Vms using UPS products.
  - Works on my local ubuntu machine (Root 6 and Boost, c++11).
  - We get 45% of total events tracked .
- Suggestion to improve the efficiency:
  - Sten suggested using events with adjacent wires
  - Prof. Craig Dukes suggested using ¾ stations

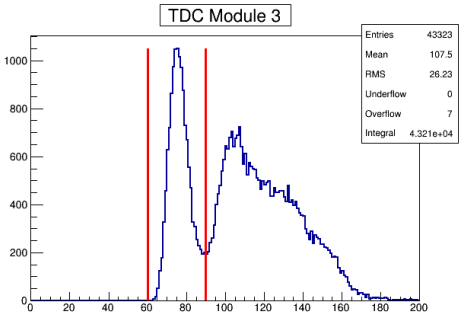
MWPC Introduction

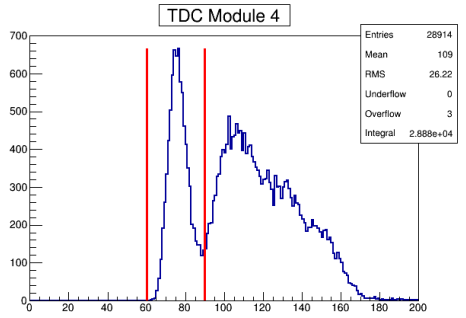
- MWPC= Multiwire Proportional Chamber
- 4 stations
- Each station consists of:
  - 128 vertical wires (for x-position)
  - 128 horizontal wires (for y-position)
  - Each set of wires is read out by 2 TDC boards(modules):
  - More details here:
    https://cdcvs.fnal.gov/redmine/projects/ftbfwirechamberdaq/wiki/Processed_hit_data_description

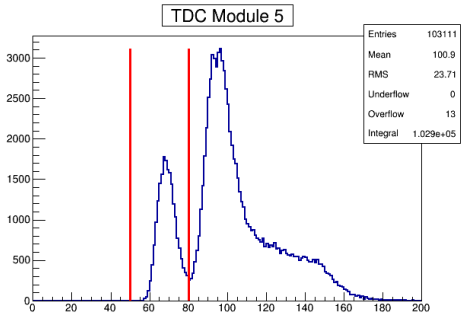


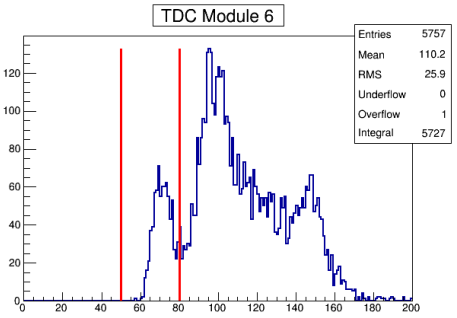

TDC Module 1
Entries 81841
Mean 108
RMS 25.37
Underflow 0
Overflow 11
Integral 8.165e+04

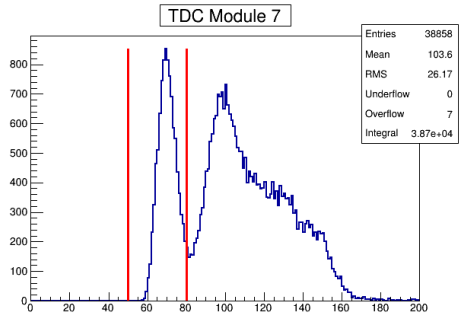

TDC Module 2
Entries 2283
Mean 113.7
RMS 27.56
Underflow 0
Overflow 0
Integral 2273

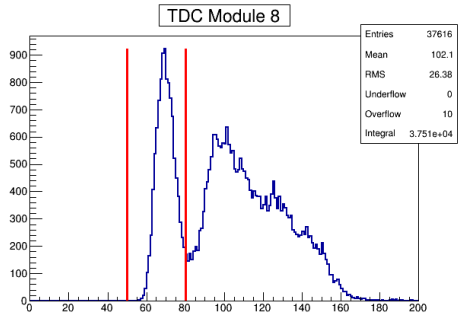

TDC Module 3
Entries 43323
Mean 107.5
RMS 26.23
Underflow 0
Overflow 7
Integral 4.321e+04

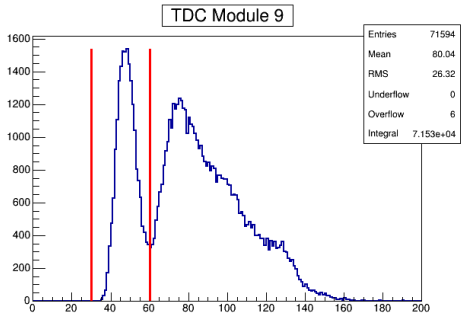

TDC Module 4
Entries 28914
Mean 109
RMS 26.22
Underflow 0
Overflow 3
Integral 2.888e+04

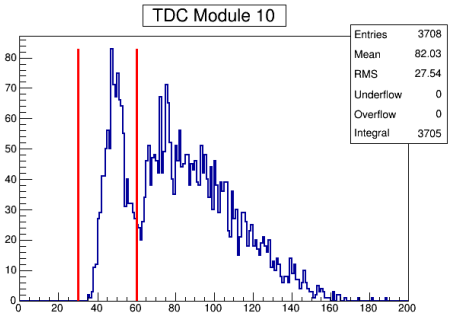

TDC Module 5
Entries 103111
Mean 100.9
RMS 23.71
Underflow 0
Overflow 13
Integral 1.029e+05

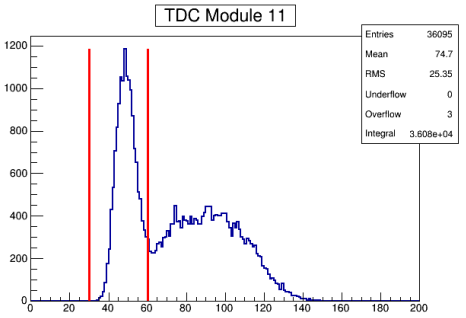

TDC Module 6
Entries 5757
Mean 110.2
RMS 25.9
Underflow 0
Overflow 1
Integral 5727

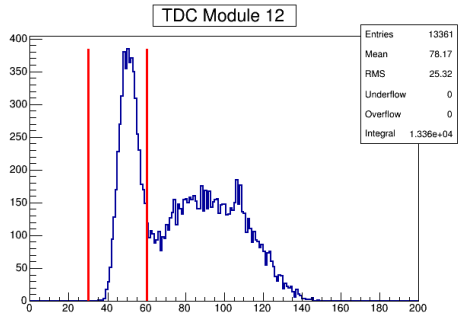

TDC Module 7
Entries 38858
Mean 103.6
RMS 26.17
Underflow 0
Overflow 7
Integral 3.87e+04

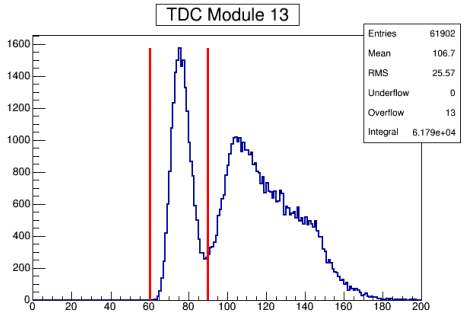

TDC Module 8
Entries 37616
Mean 102.1
RMS 26.38
Underflow 0
Overflow 10
Integral 3.751e+04

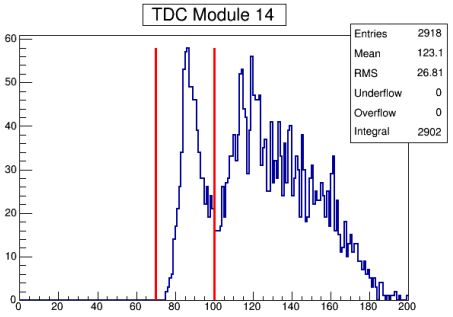

TDC Module 9
Entries 71594
Mean 80.04
RMS 26.32
Underflow 0
Overflow 6
Integral 7.153e+04

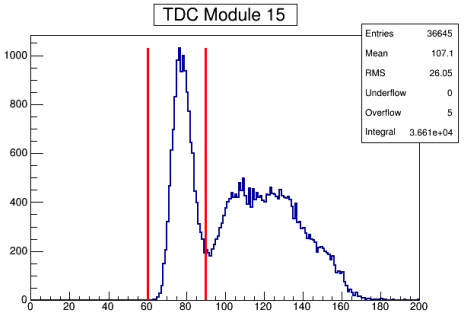

TDC Module 10
Entries 3708
Mean 82.03
RMS 27.54
Underflow 0
Overflow 0
Integral 3705

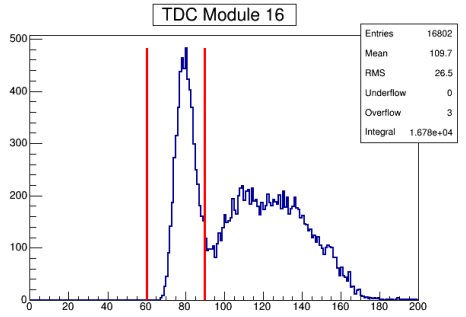

TDC Module 11
Entries 36095
Mean 74.7
RMS 25.35
Underflow 0
Overflow 3
Integral 3.608e+04


TDC Module 12
Entries 13361
Mean 78.17
RMS 25.32
Underflow 0
Overflow 0
Integral 1.336e+04


TDC Module 13
Entries 61902
Mean 106.7
RMS 25.57
Underflow 0
Overflow 13
Integral 6.179e+04


TDC Module 14
Entries 2918
Mean 123.1
RMS 26.81
Underflow 0
Overflow 0
Integral 2902


TDC Module 15
Entries 36645
Mean 107.1
RMS 26.05
Underflow 0
Overflow 5
Integral 3.661e+04

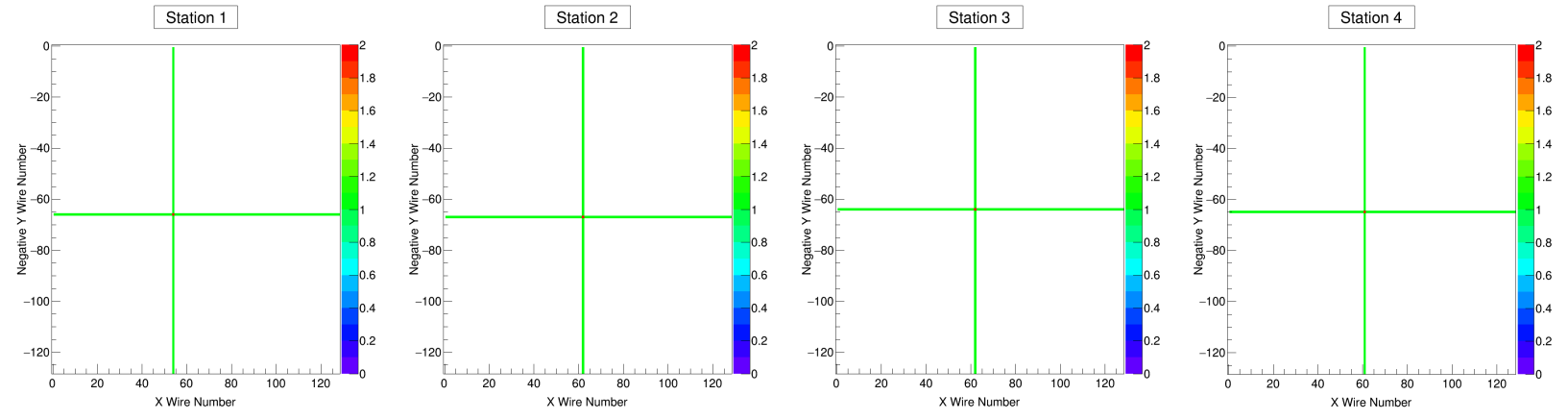

TDC Module 16
Entries 16802
Mean 109.7
RMS 26.5
Underflow 0
Overflow 3
Integral 1.678e+04

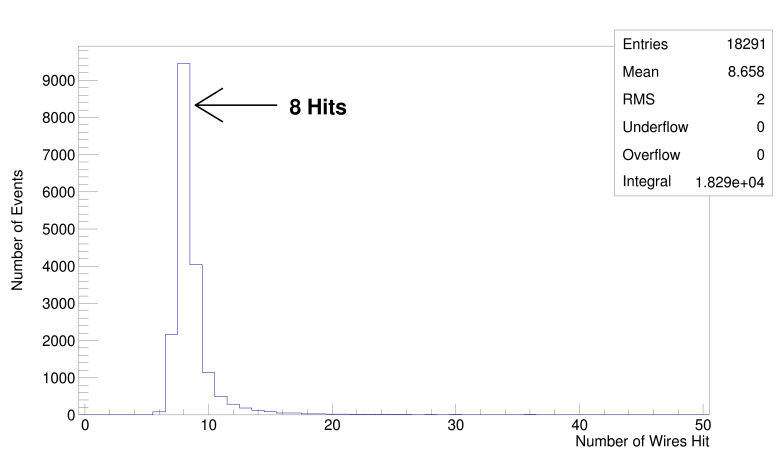
TDC Range

- A good hit is a hit that has a TDC value in the following TDC ranges (shown in red on previous slide) :
  - Modules 1-4: (60 TDC, 90 TDC)
  - Modules 5-8: (50 TDC, 80 TDC)
  - Modules 9-12: (30 TDC, 60 TDC)
  - Modules 13, 15, 16: (60 TDC, 90 TDC)
  - Module 14: (70 TDC, 100 TDC)
- These thresholds were determined by eye. For the run in May and June the TDC range is slightly different. It's in the back-up slides.

Normal Event

- A normal event should have x and y hit on each station. 4 stations, 8 hits.



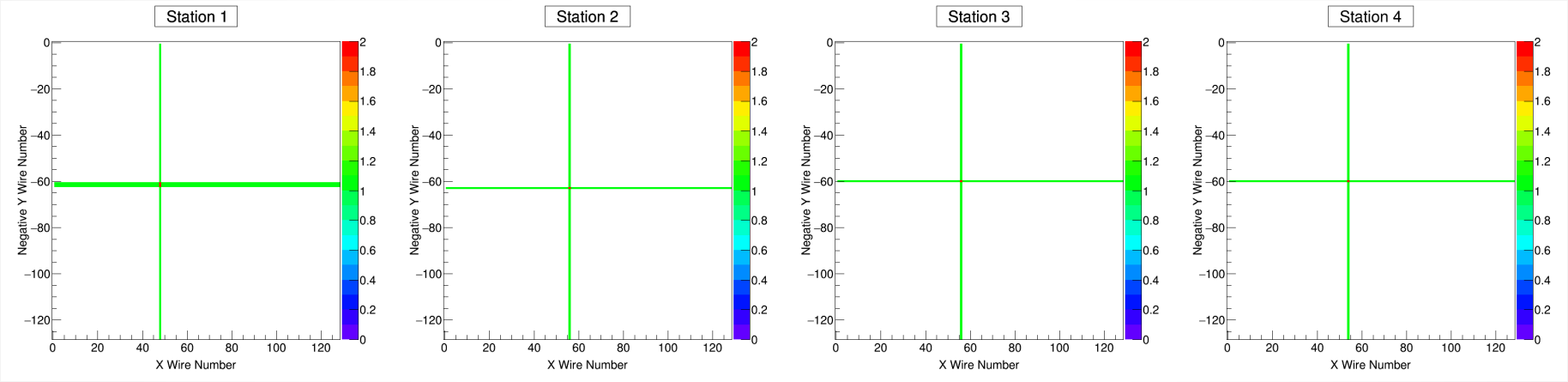


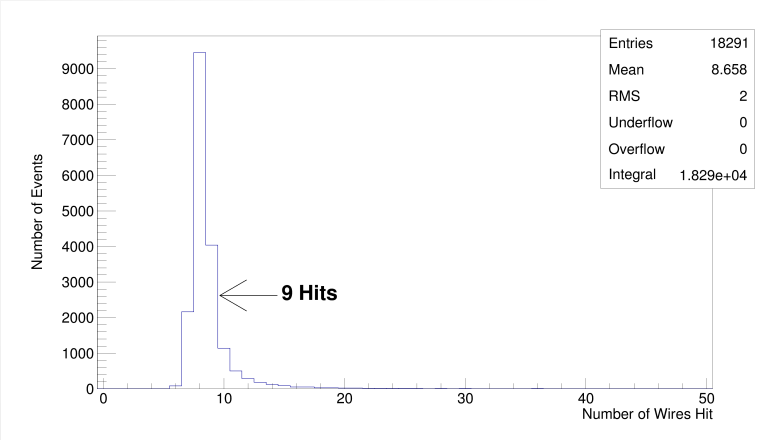
The left histogram shows the number of wires hit per event. Parsed 19279 events, tracked 8722 events. 45%

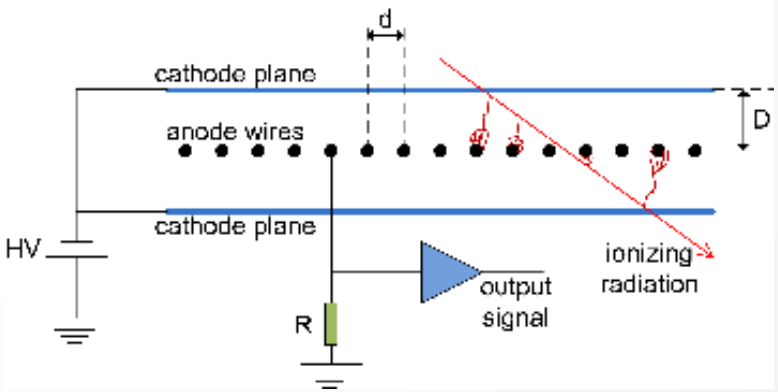
The top shows an event display of an event where exactly 8 wires were hit.

Adjacent Hits

- 35% of all events have adjacent wires hit.
- The top shows an event display of an event where 9 wires were hit. Two adjacent wires of station 1 Y axis were hit.
- The bottom left histogram shows the number of wires hit per event.
- The bottom right explain the reason of adjacent wires hit event.







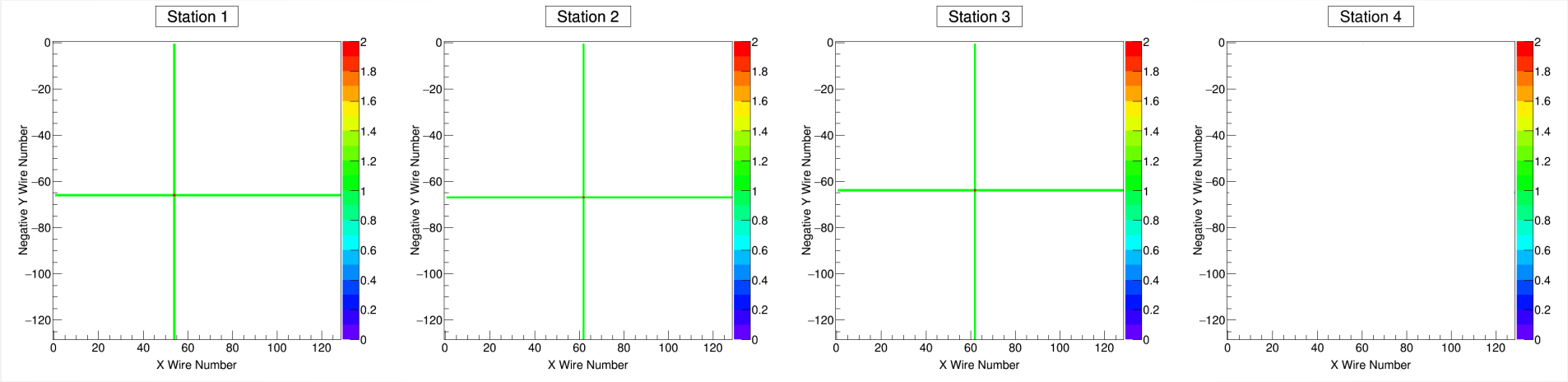
Exaggeration, real beam is perpendicular to the surface of MWPC.

Using Adjacent Hits

- The event has at least one x and one y hit on each station (at least 8 hits total).
- Allow up to 4 adjacent wires.
- Use average position of adjacent wires.
- This method tracks 78% (15,070/19,279) of all events.

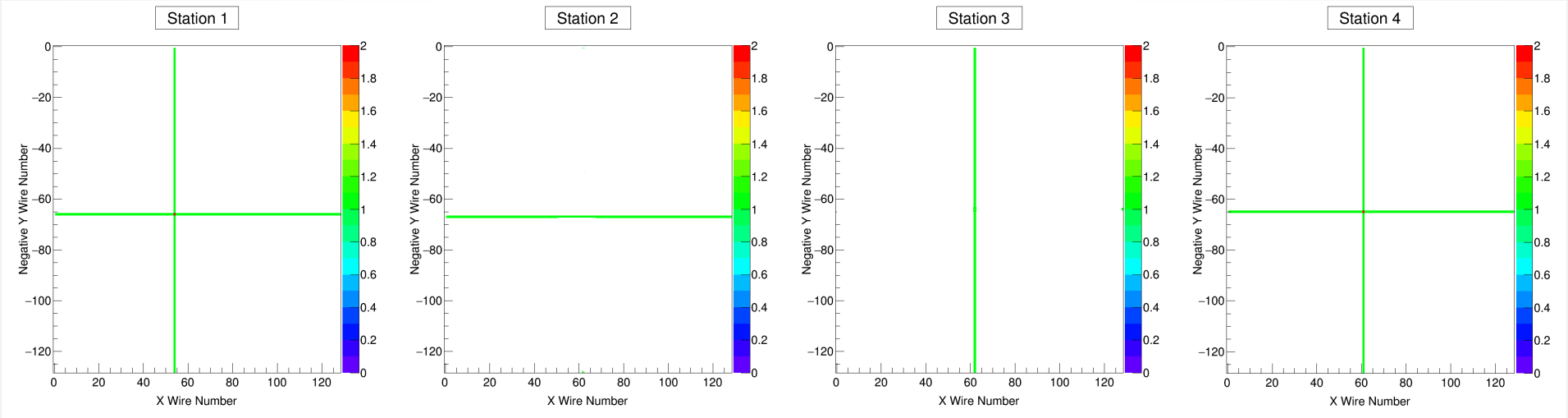
Use 3 out of 4 Stations

- Next step, we want to track events with less than 8 hits.
- This shows an event display of an event where 6 wires of 3 stations were hit.



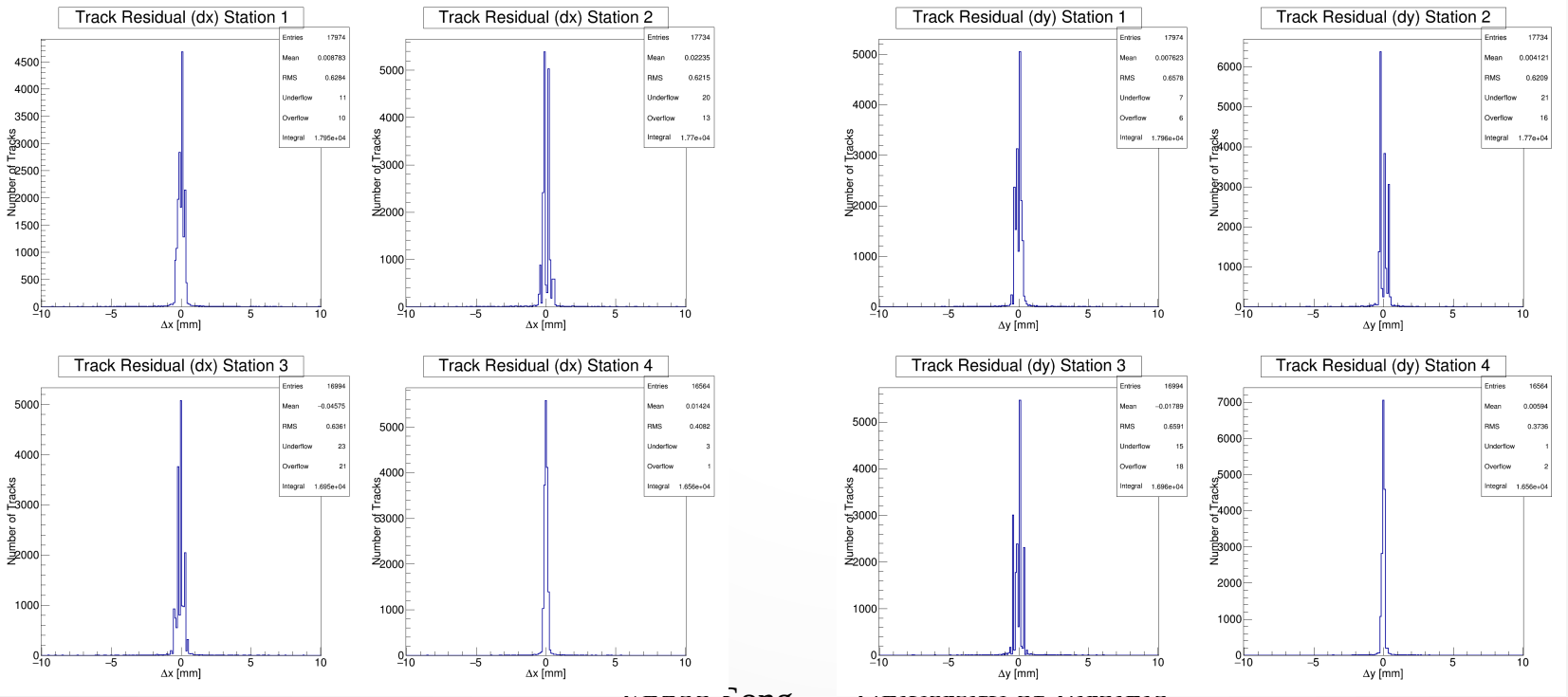
Bad Event

- This shows an event display of a bad event.



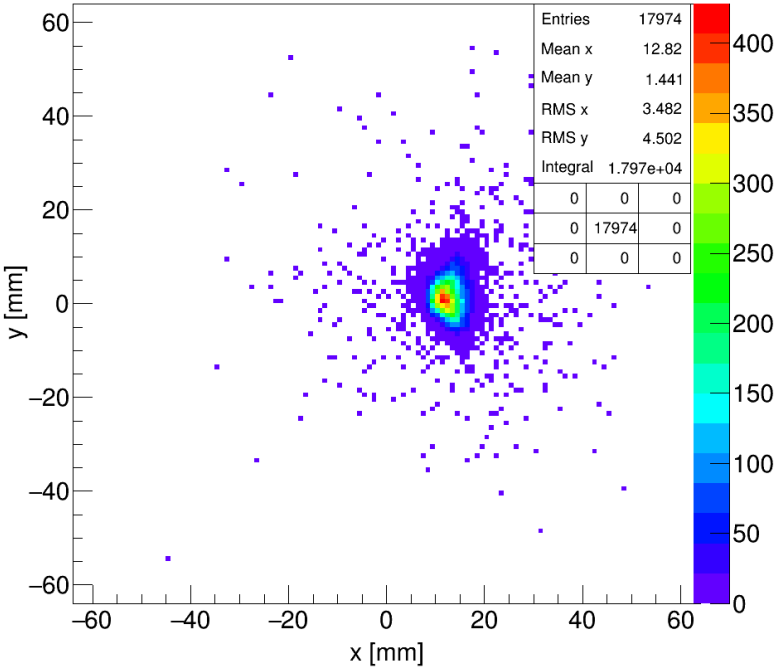
Result

- Increased efficiency from 40% to 95% (18,291/19,279).
- Resolution is good
- Left is the track residual for dx, right is the track residual for dy.

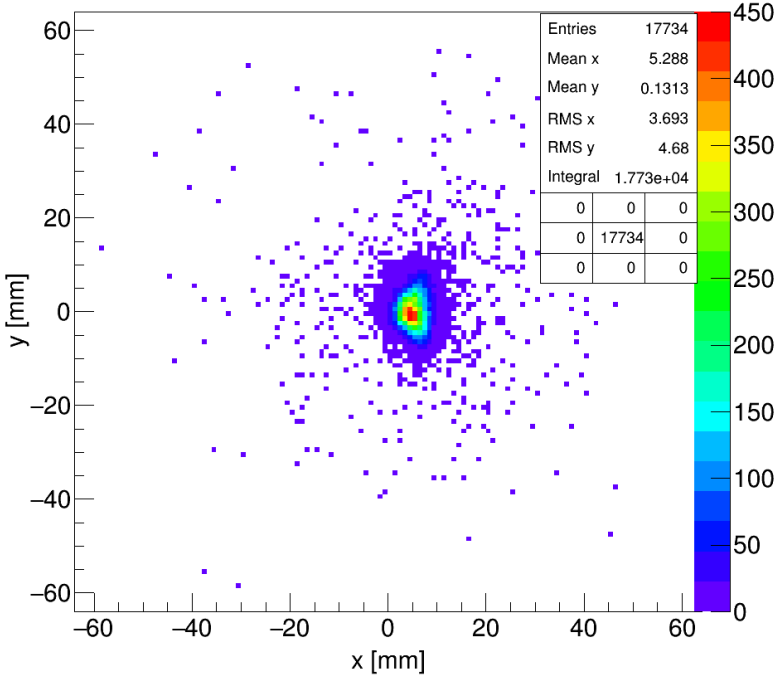


This is for May run, for June run it is different , in back-up

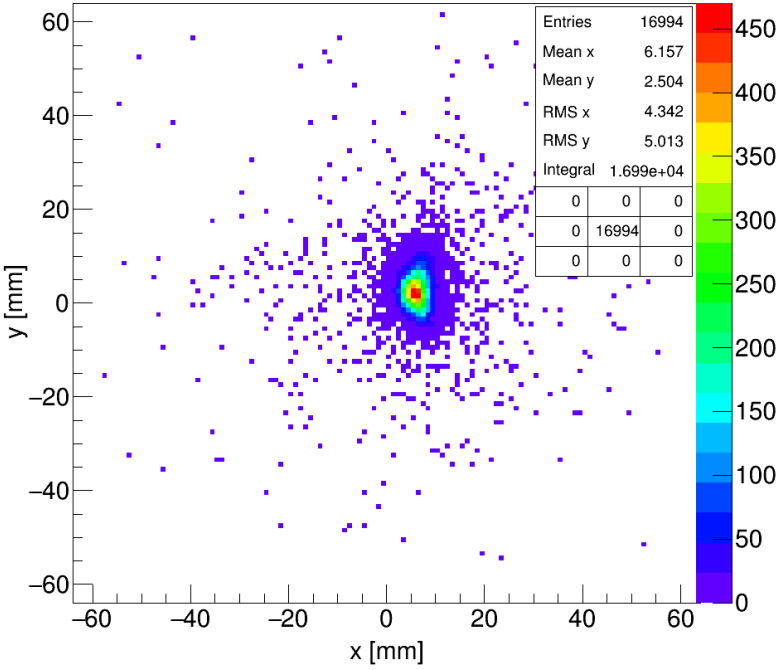
XY Position Station 1



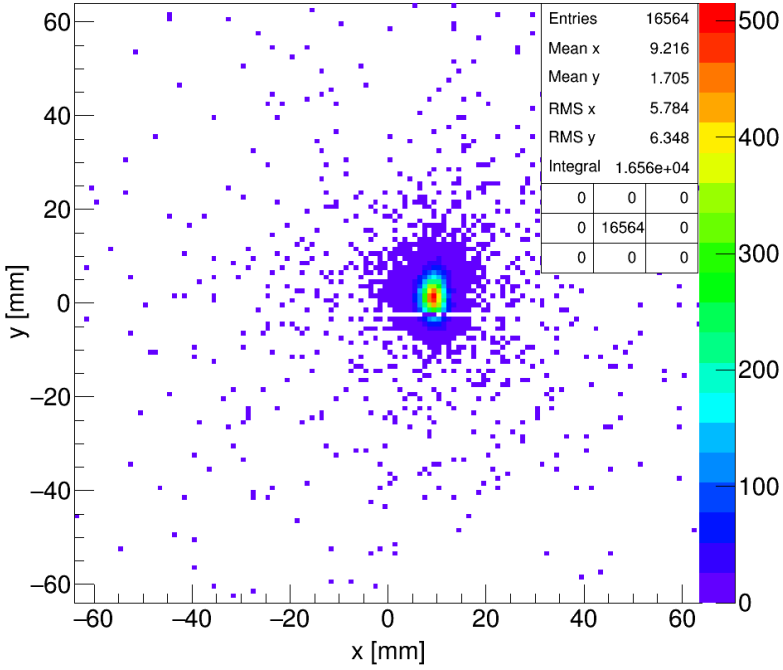
XY Position Station 2



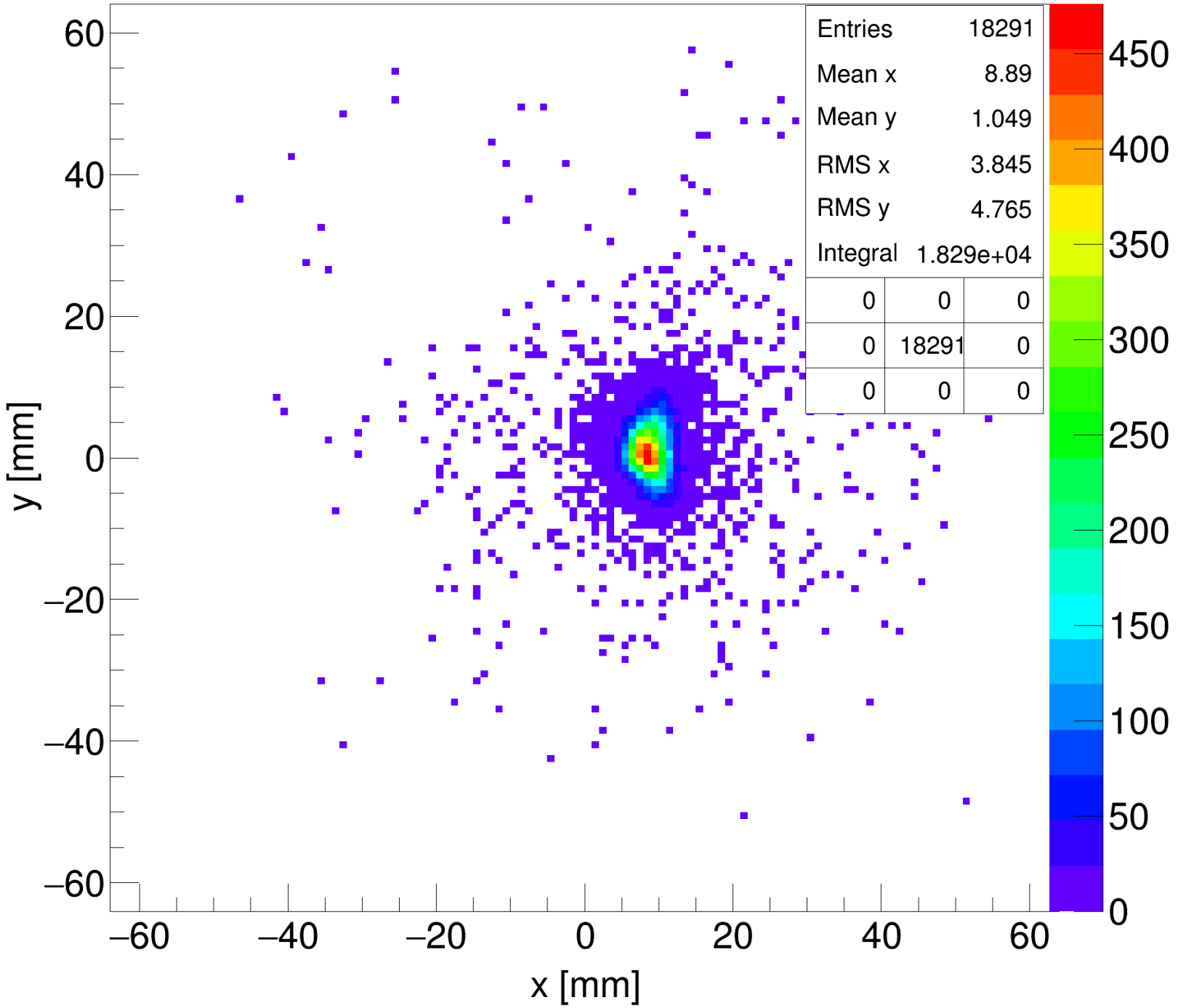
XY Position Station 3



XY Position Station 4



XY Position at CRV

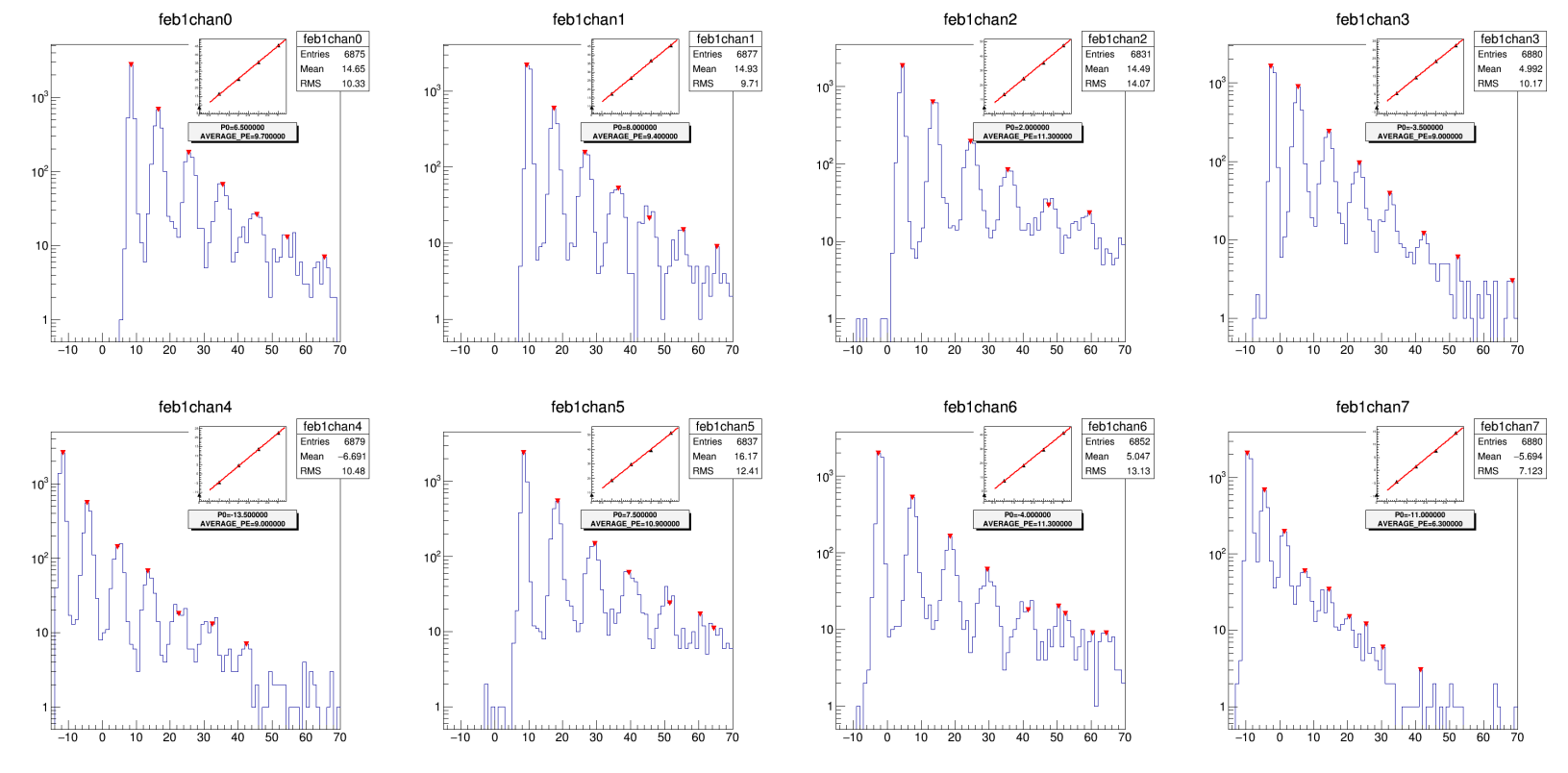


Combine MWPC and CRV Data

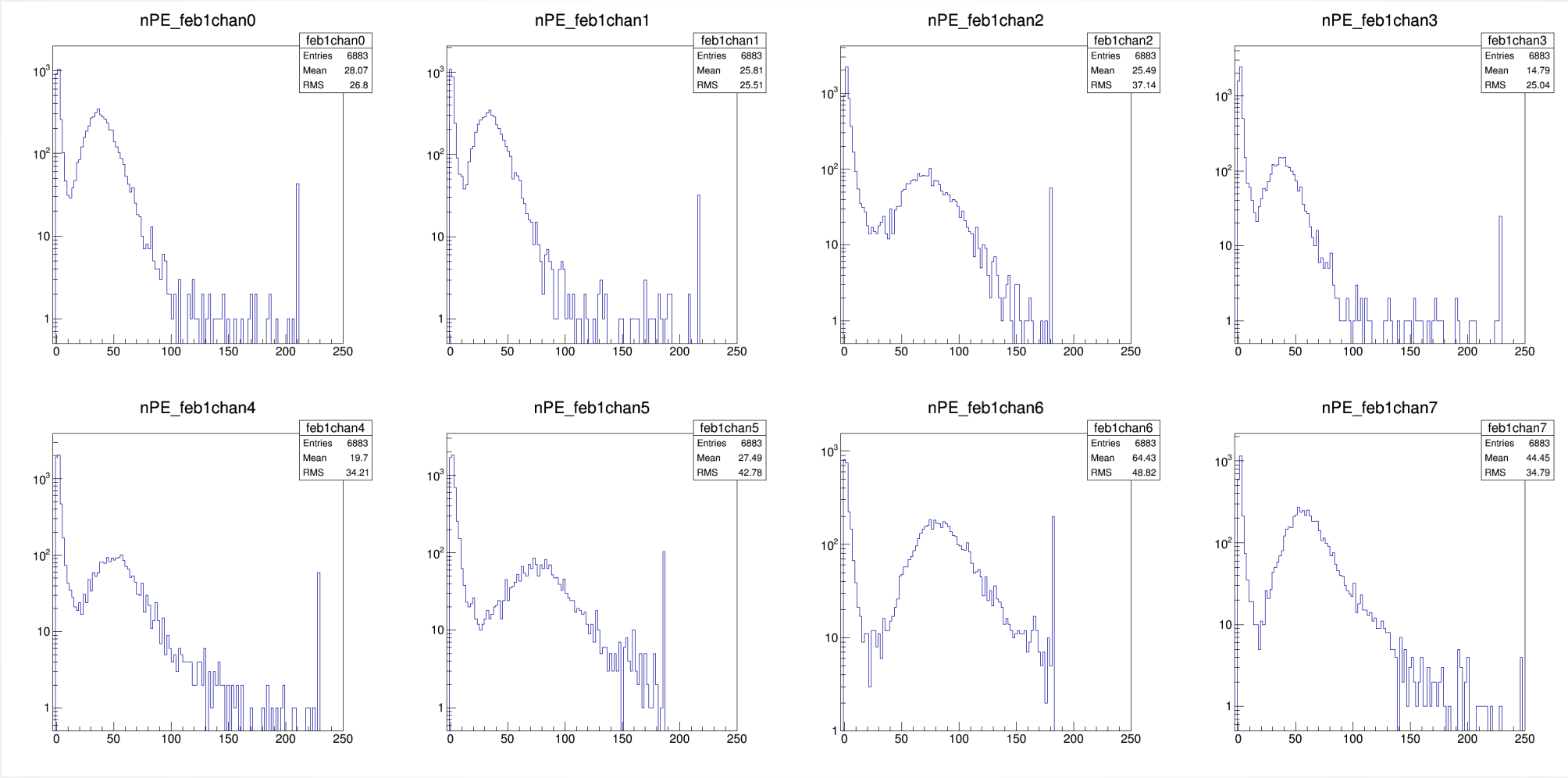
- Thanks Martin for merging the MWPC and CRV root file.
- In order for an event to be put into the output tree, it has to have a track from the MWPC, 16 channels from the CRV and meet the following matching criteria :
  - same spill count
  - same event count
  - same number of events in spill
  - time since spill has to be within 2 us of each other

PE calibration

- Calibration of the merged root file for single PE.
- Yongyi told me use the TDC range 0 to 45.

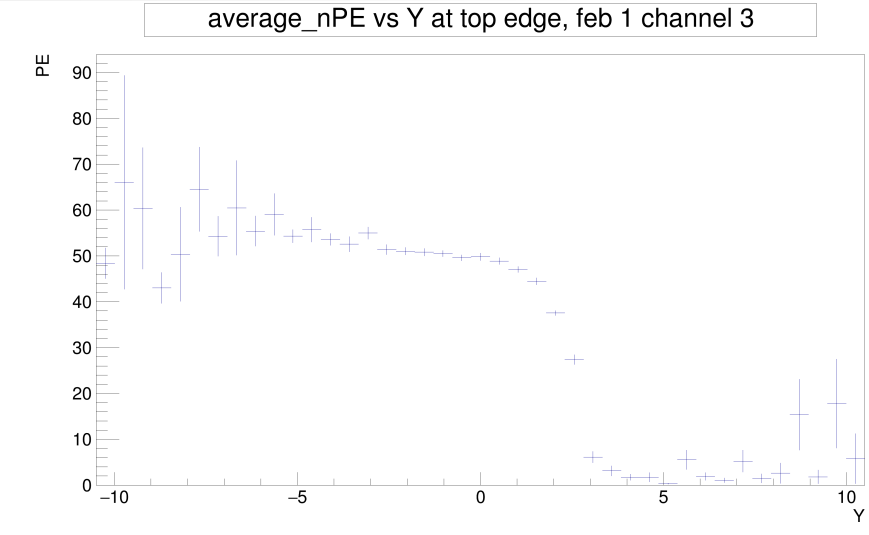


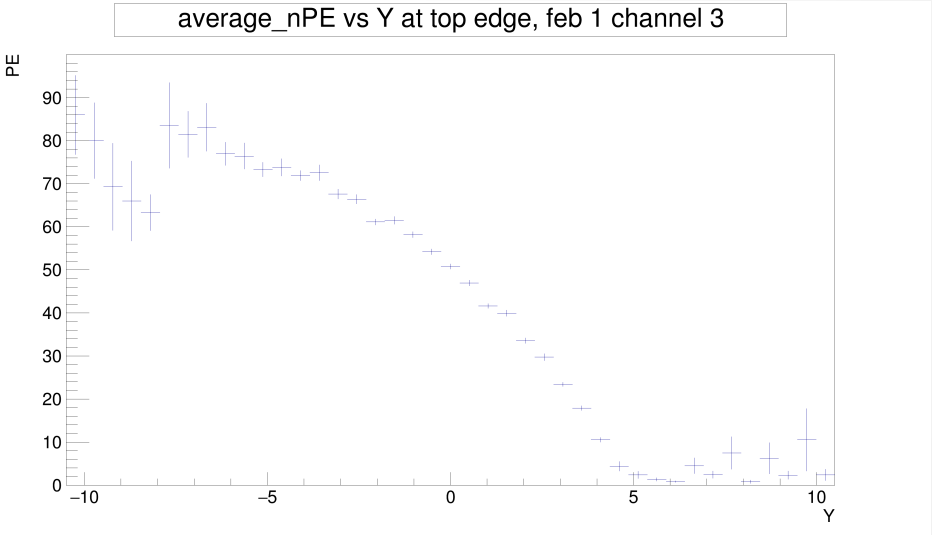
PE distribution



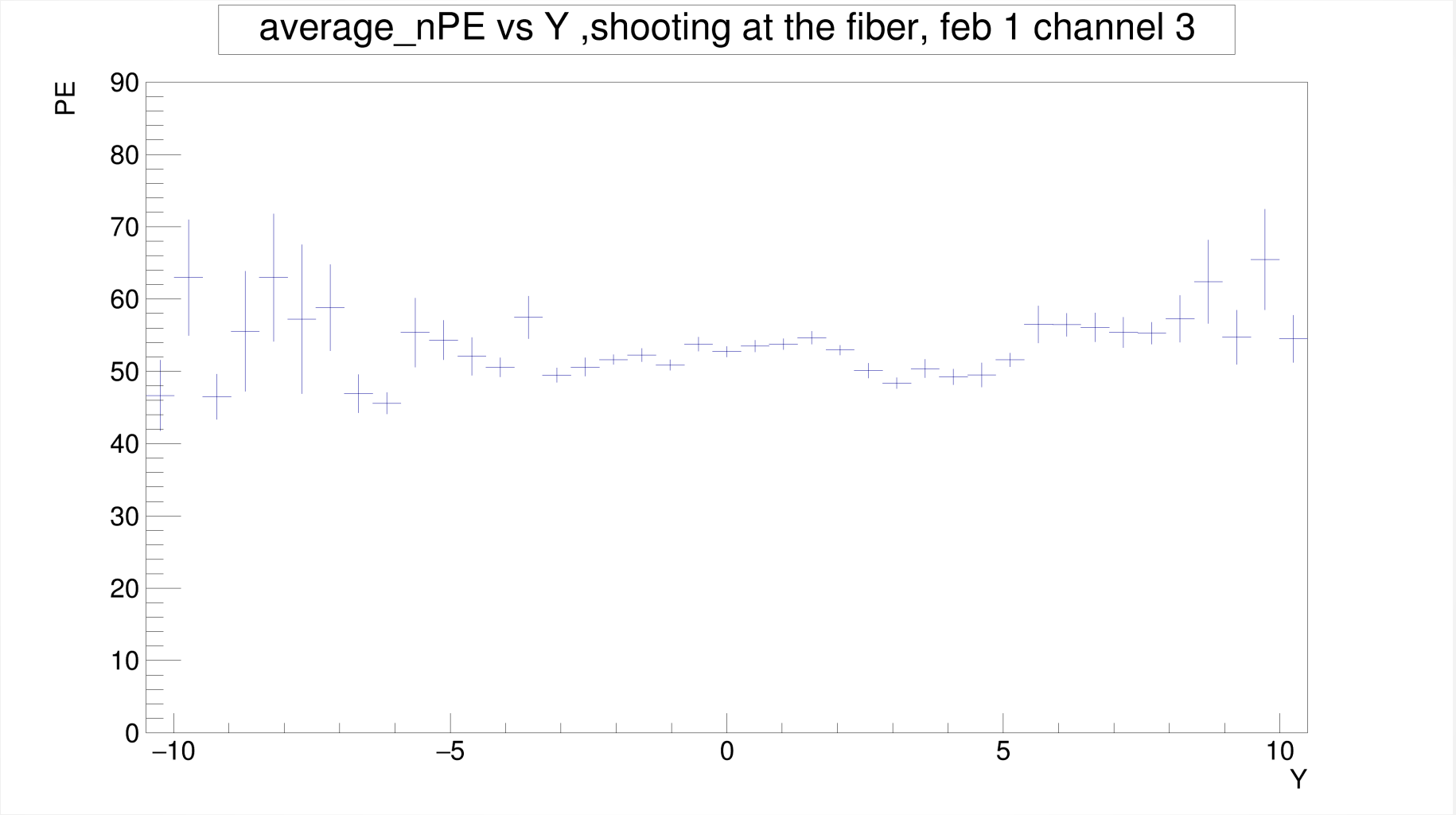
Top edge scan

- Left is 90 deg.(run0171), right is 60 deg.(run0229).



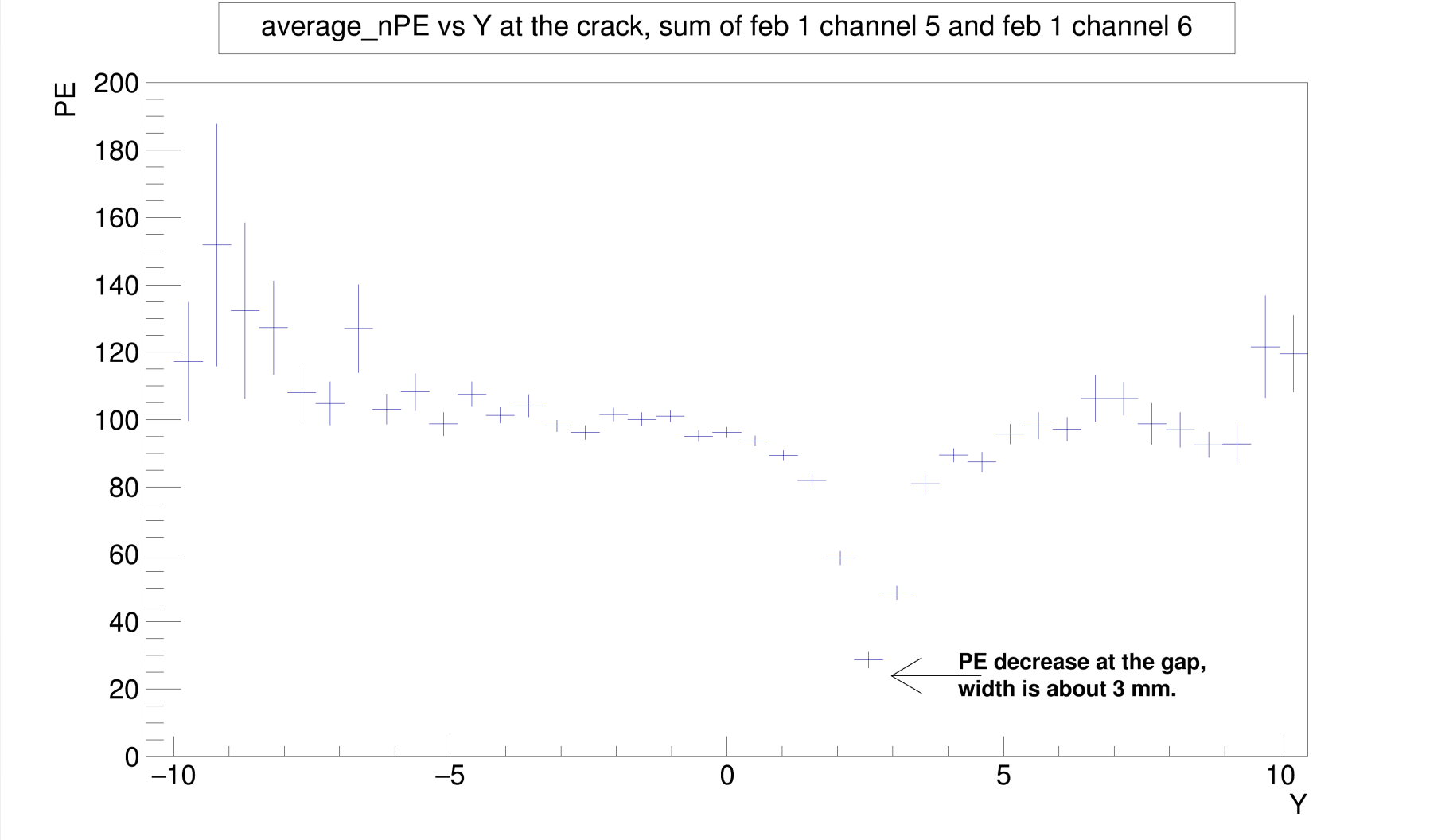


Fiber scan



run0171

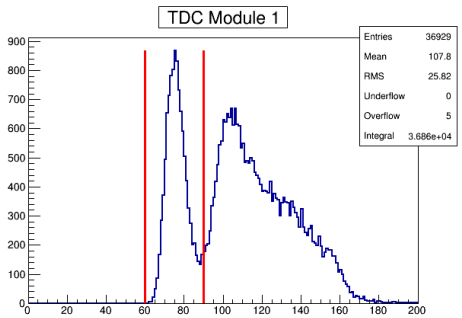
Gap scan

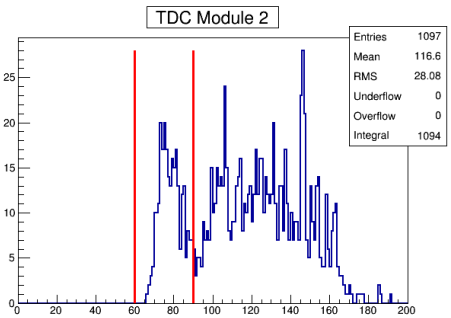


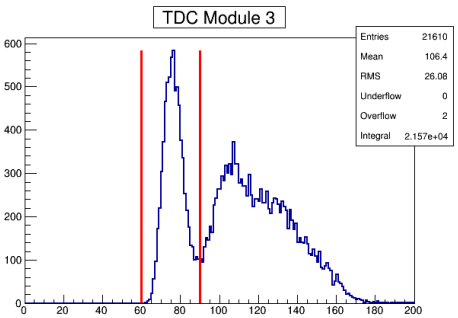
run0176

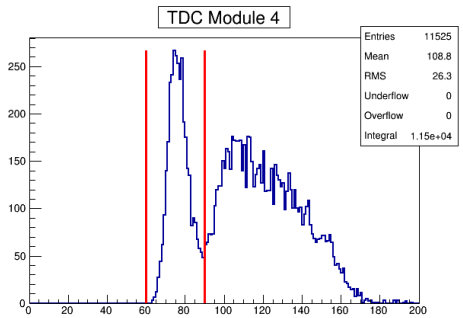
- Thank you!

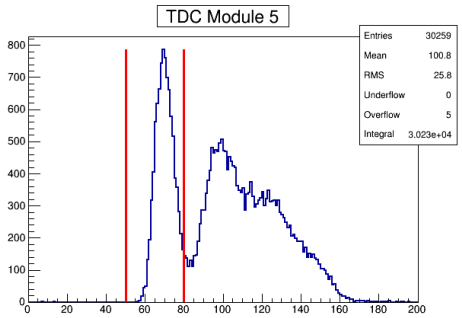
Back-up Slides

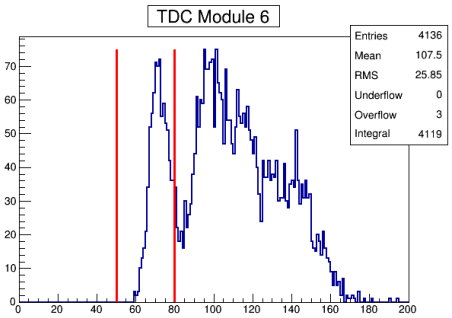

TDC Module 1
Entries 36929
Mean 107.8
RMS 25.82
Underflow 0
Overflow 5
Integral 3.686e+04

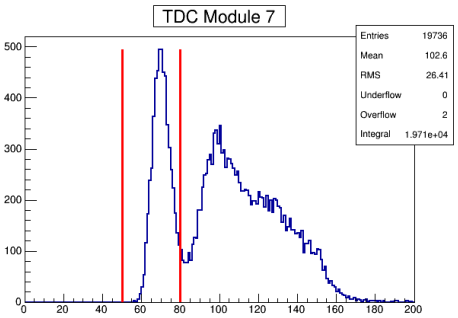

TDC Module 2
Entries 1097
Mean 116.6
RMS 28.08
Underflow 0
Overflow 0
Integral 1094

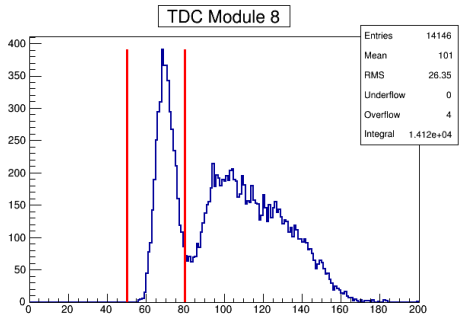

TDC Module 3
Entries 21610
Mean 106.4
RMS 26.08
Underflow 0
Overflow 2
Integral 2.157e+04

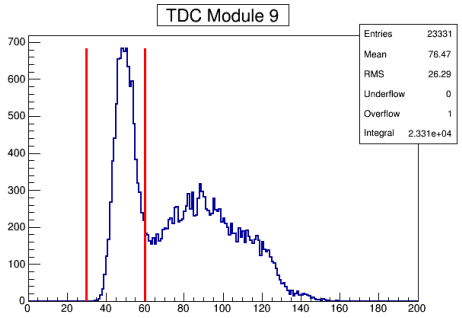

TDC Module 4
Entries 11525
Mean 108.8
RMS 26.3
Underflow 0
Overflow 0
Integral 1.15e+04

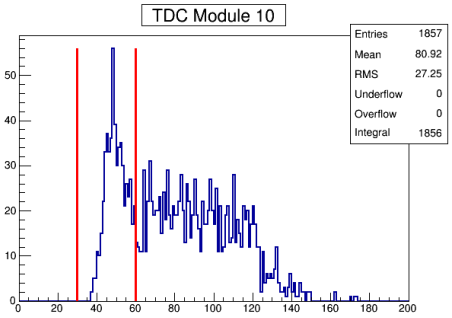

TDC Module 5
Entries 30259
Mean 100.8
RMS 25.8
Underflow 0
Overflow 5
Integral 3.023e+04

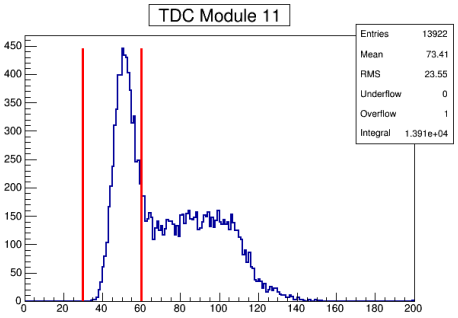

TDC Module 6
Entries 4136
Mean 107.5
RMS 25.85
Underflow 0
Overflow 3
Integral 4119

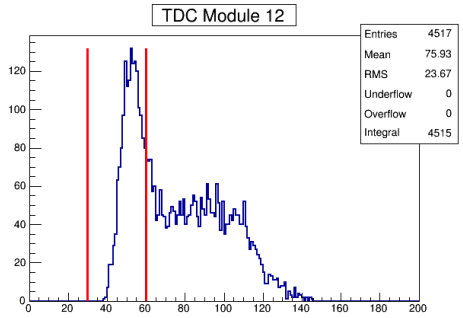

TDC Module 7
Entries 19736
Mean 102.6
RMS 26.41
Underflow 0
Overflow 2
Integral 1.971e+04

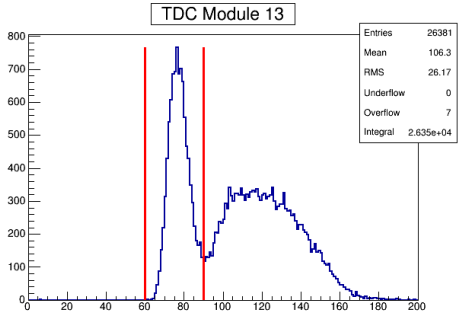

TDC Module 8
Entries 14146
Mean 101
RMS 26.35
Underflow 0
Overflow 4
Integral 1.412e+04

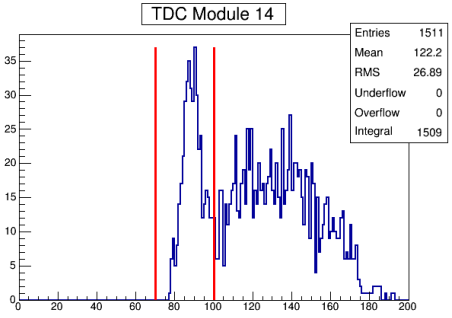

TDC Module 9
Entries 23331
Mean 76.47
RMS 26.29
Underflow 0
Overflow 1
Integral 2.331e+04

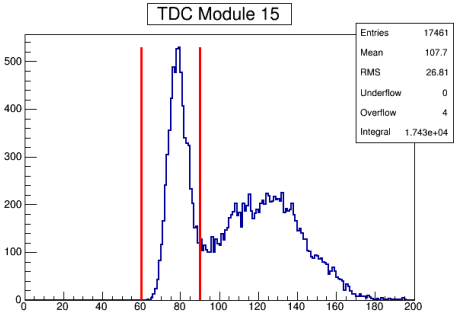

TDC Module 10
Entries 1857
Mean 80.92
RMS 27.25
Underflow 0
Overflow 0
Integral 1856

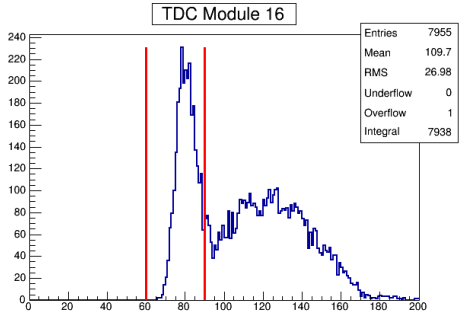

TDC Module 11
Entries 13922
Mean 73.41
RMS 23.55
Underflow 0
Overflow 1
Integral 1.391e+04


TDC Module 12
Entries 4517
Mean 75.93
RMS 23.67
Underflow 0
Overflow 0
Integral 4515


TDC Module 13
Entries 26381
Mean 106.3
RMS 26.17
Underflow 0
Overflow 7
Integral 2.635e+04

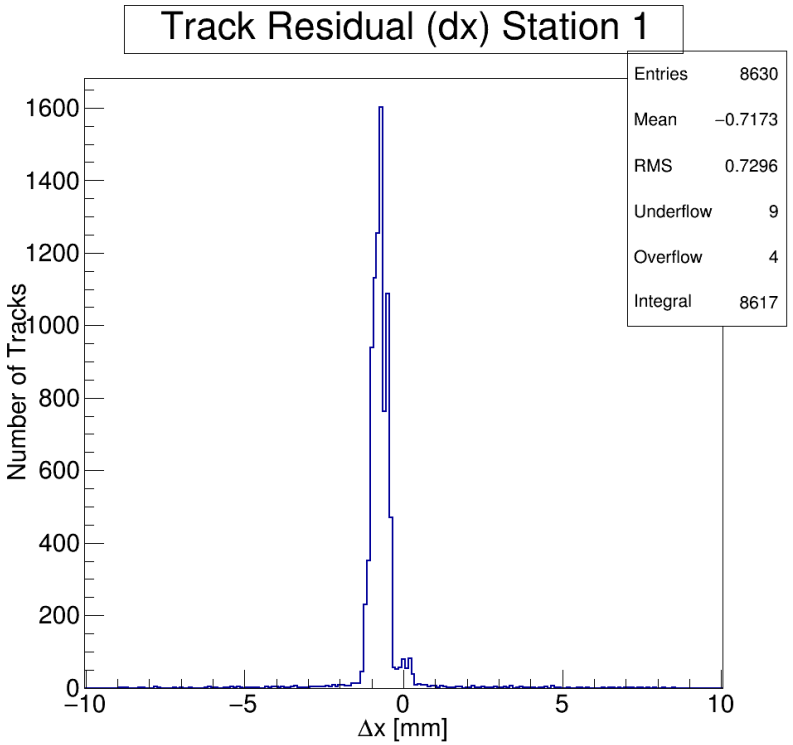

TDC Module 14
Entries 1511
Mean 122.2
RMS 26.89
Underflow 0
Overflow 0
Integral 1509

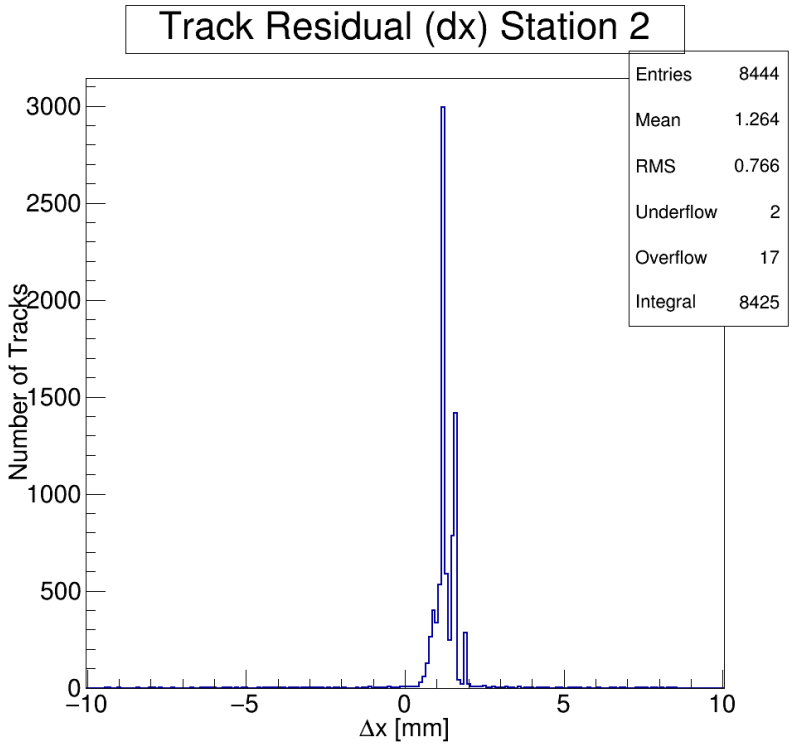

TDC Module 15
Entries 17461
Mean 107.7
RMS 26.81
Underflow 0
Overflow 4
Integral 1.743e+04

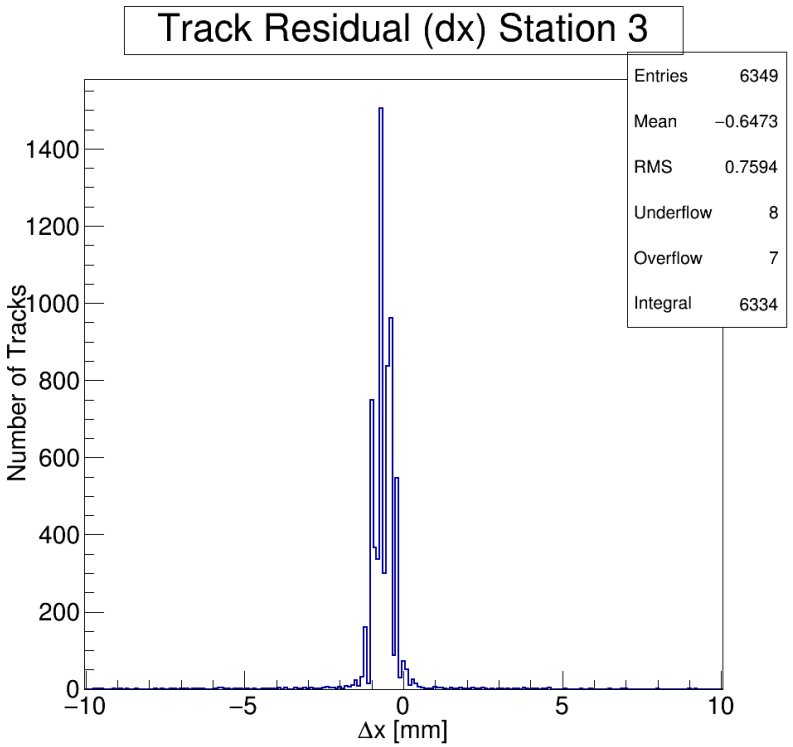

TDC Module 16
Entries 7955
Mean 109.7
RMS 26.98
Underflow 0
Overflow 1
Integral 7938

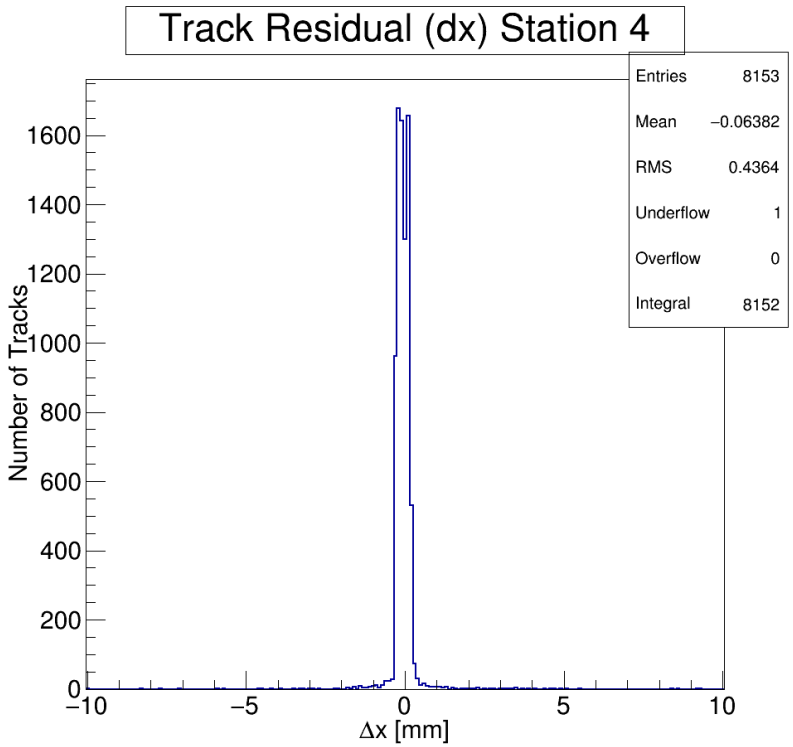
TDC Range for June

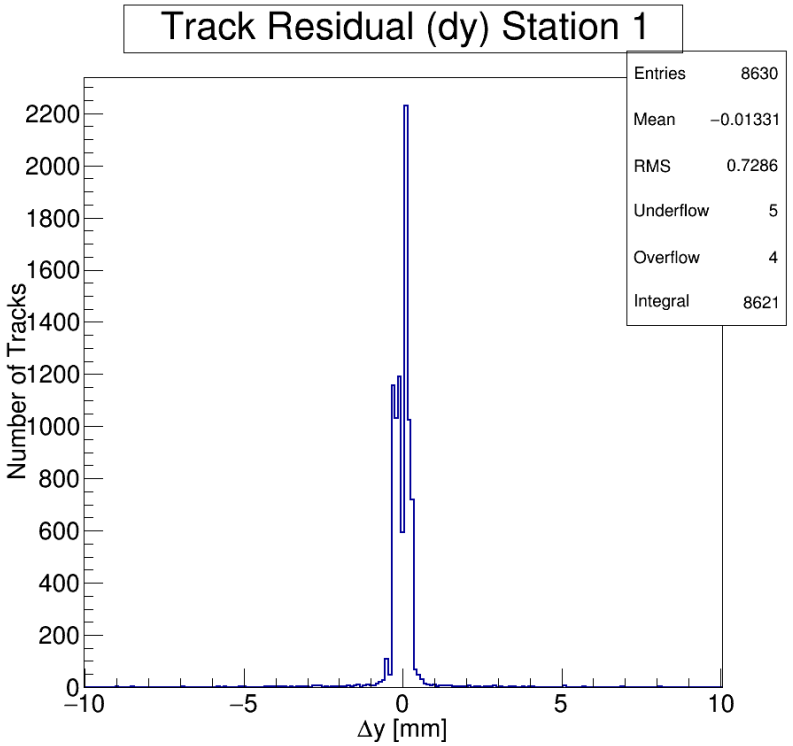
- A good hit is a hit that has a TDC value in the following TDC ranges (shown in red on previous slide) :
  - Modules 1-4: (60 TDC, 90 TDC)
  - Modules 5-8: (50 TDC, 80 TDC)
  - Modules 9-10: (30 TDC, 60 TDC)
  - Modules 11-12: (30 TDC, 70 TDC)
  - Modules 13, 15, 16: (60 TDC, 90 TDC)
  - Module 14: (70 TDC, 100 TDC)

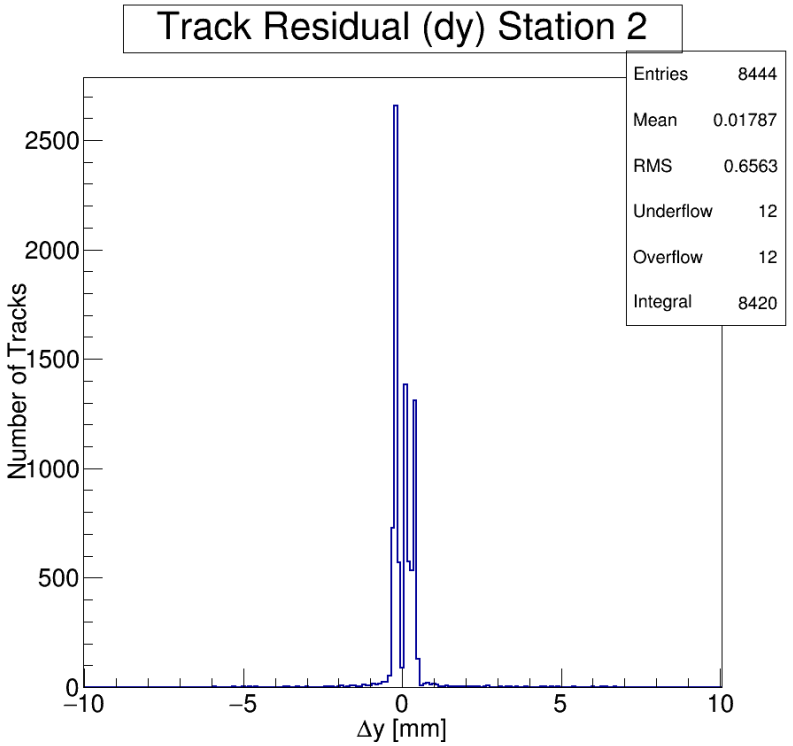

Track Residual (dx) Station 1
Entries 8630
Mean −0.7173
RMS 0.7296
Underflow 9
Overflow 4
Integral 8617
Number of Tracks
Δx [mm]

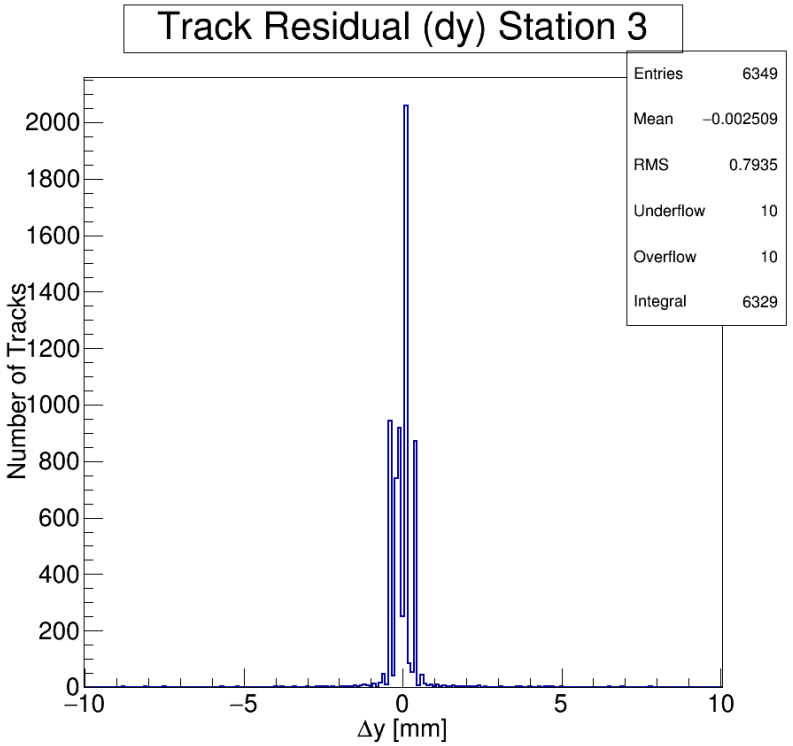

Track Residual (dx) Station 2
Entries 8444
Mean 1.264
RMS 0.766
Underflow 2
Overflow 17
Integral 8425
Number of Tracks
Δx [mm]

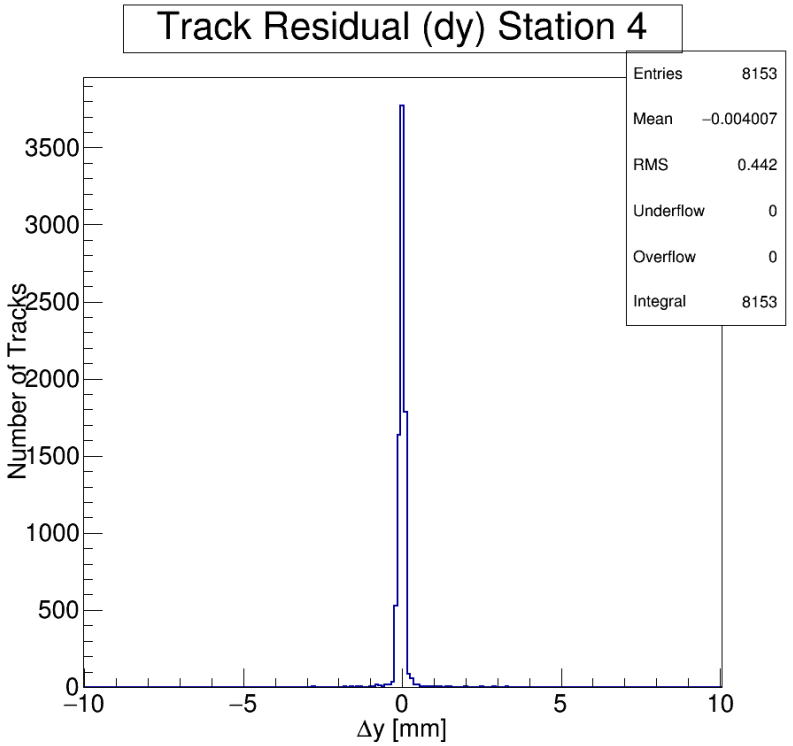

Track Residual (dx) Station 3
Entries 6349
Mean −0.6473
RMS 0.7594
Underflow 8
Overflow 7
Integral 6334
Number of Tracks
Δx [mm]


Track Residual (dx) Station 4
Entries 8153
Mean −0.06382
RMS 0.4364
Underflow 1
Overflow 0
Integral 8152
Number of Tracks
Δx [mm]


Track Residual (dy) Station 1
Entries 8630
Mean −0.01331
RMS 0.7286
Underflow 5
Overflow 4
Integral 8621
Number of Tracks
Δy [mm]


Track Residual (dy) Station 2
Entries 8444
Mean 0.01787
RMS 0.6563
Underflow 12
Overflow 12
Integral 8420
Number of Tracks
Δy [mm]


Track Residual (dy) Station 3
Entries 6349
Mean −0.002509
RMS 0.7935
Underflow 10
Overflow 10
Integral 6329
Number of Tracks
Δy [mm]

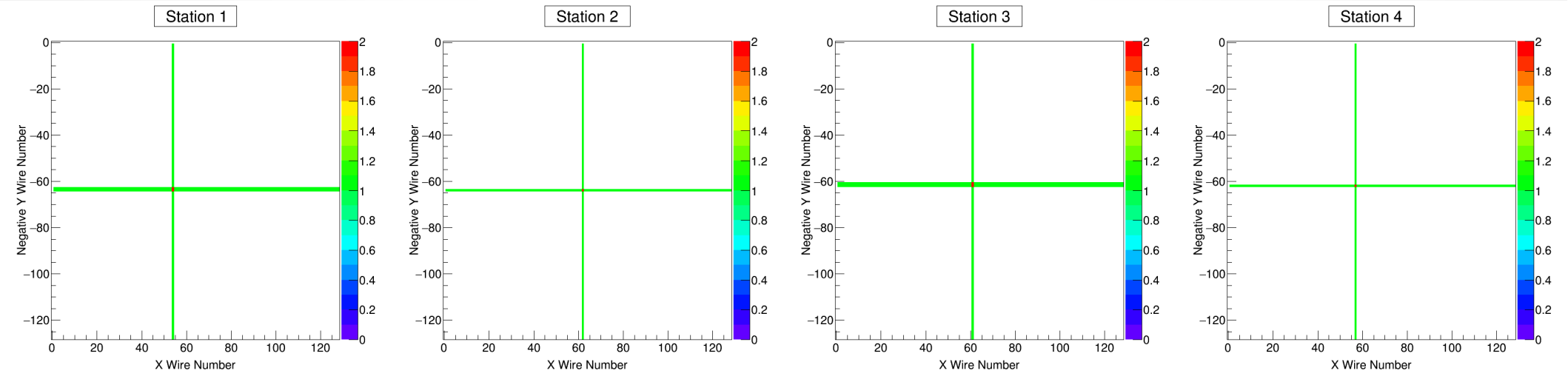

Track Residual (dy) Station 4
Entries 8153
Mean −0.004007
RMS 0.442
Underflow 0
Overflow 0
Integral 8153
Number of Tracks
Δy [mm]

Track Residual

- The track residual in X is -0.71 mm for station 1, 1.26 mm for station 2, and -0.64 for station 3, so we should adjust the offsets.
- The residuals in the Y direction all still have means within 0.1 mm.

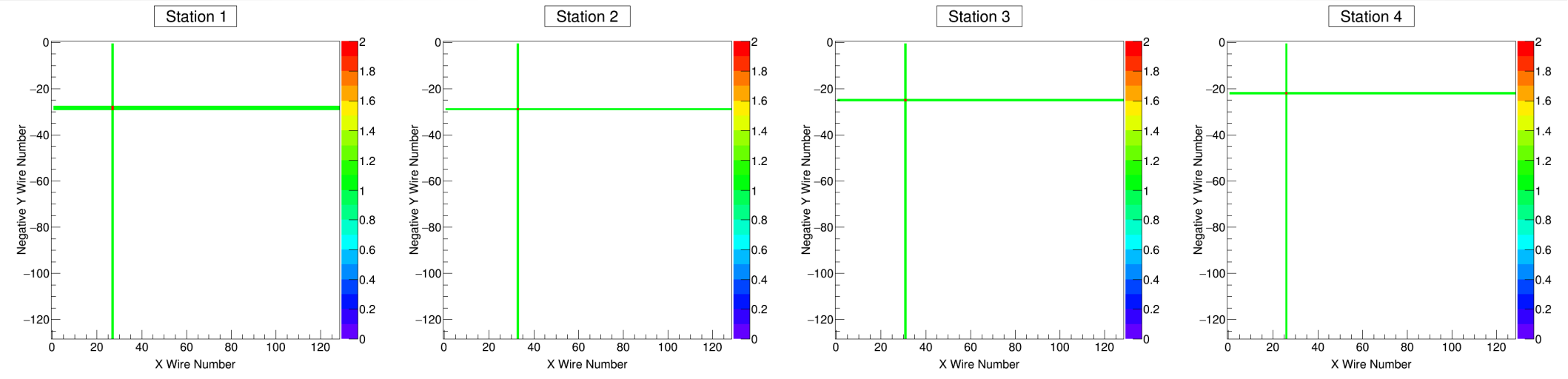
Event Display

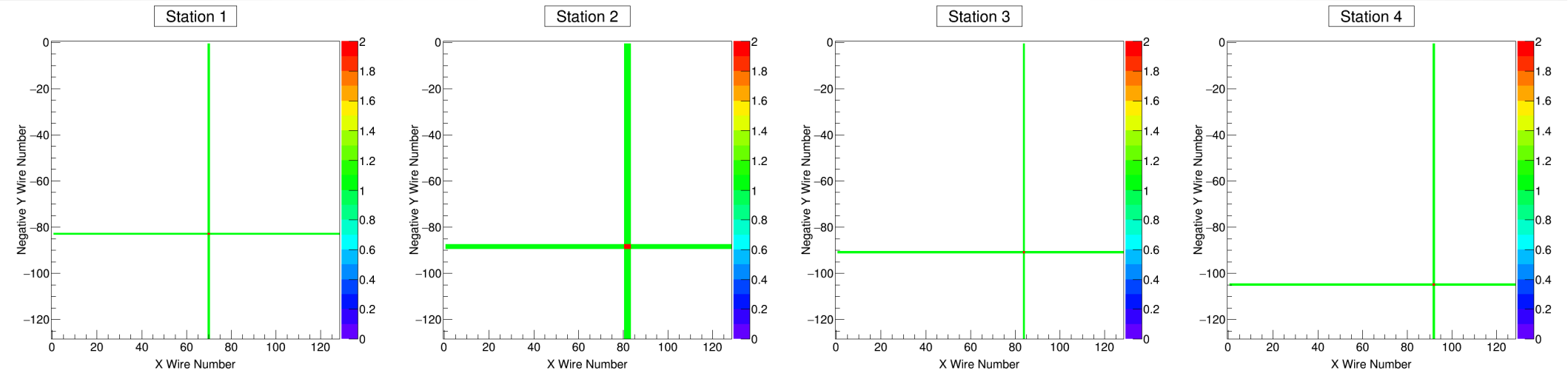
- Bottom is an event of 10 hits.



Event Display

- Bottom is an event that is off the centor of mwpc.



Event Display

- Bottom shows a proton which is scattered between station 3 and station 4.